Computer Modeling of the Laboratory Testing of Mini- Magnetospheric Plasma Propulsion (M2P2)

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Recent laboratory testing has demonstrated that the mini-magnetospheric plasma propulsion (M2P2) prototype is able to (1) efficiently produce plasma, (2) expand magnetic field lines and produce an inflated magnetosphere, and (3) deflect an external plasma source at large distances. Multi-fluid computer simulations are used to model the experimental configuration with the objective of quantifying the characteristics of the magnetic field inflation, and its deflection of an external plasma wind. The simulations show that the injection of plasma onto the closed field lines of the magnet, equatorial magnetic flux is carried out by the plasma and results in an increase in magnetic flux away from the magnet until obstructed by the chamber walls. The spatial and temporal profiles of the magnetic field perturbations derived from the simulations are shown to be consistent with the laboratory data and show the full extent of the prototype's ability to transport magnetic flux and inflate a mini-magnetosphere. Deflection of an external plasma source by the M2P2 prototype is also investigated. The simulations show that the plasma wind will be deflected by the inflated mini-magnetosphere. This deflection leads to a depletion of wind plasma in the near vicinity of the mini-magnetosphere. It is also produces a broadening and compression of the plasma plume close to the external plasma source. These very distinctive features are identified in images of the actual experiment. If the same device were deployed in space the computer modeling indicates that they could expand a mini-magnetosphere 10-20 km in radius to achieve a thrust level 1-3 N with the expenditure of only a few kW of power at less than 1 kg per day propellant consumption.

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